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David A. Ladner
Clemson University

Peng Xie
Clemson University

Ying Tu
Clemson University

Nicholas K. Geitner
Clemson University

Sean Powers
University of South Alabama

See next page for additional authors

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Authors

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Dendritic polymers as oil spill dispersants: Effectiveness and toxicity compared to Corexit 9500A

David A. Ladner^{1*}, Peng Xie¹, Ying Tu¹, Nicholas K. Geitner², Sean Powers³, Andrew Whelton⁴, Pu Chun Ke²

¹Department of Environmental Engineering and Earth Sciences, Clemson University

²Department of Physics and Astronomy, Clemson University

³Department of Marine Sciences, University of South Alabama

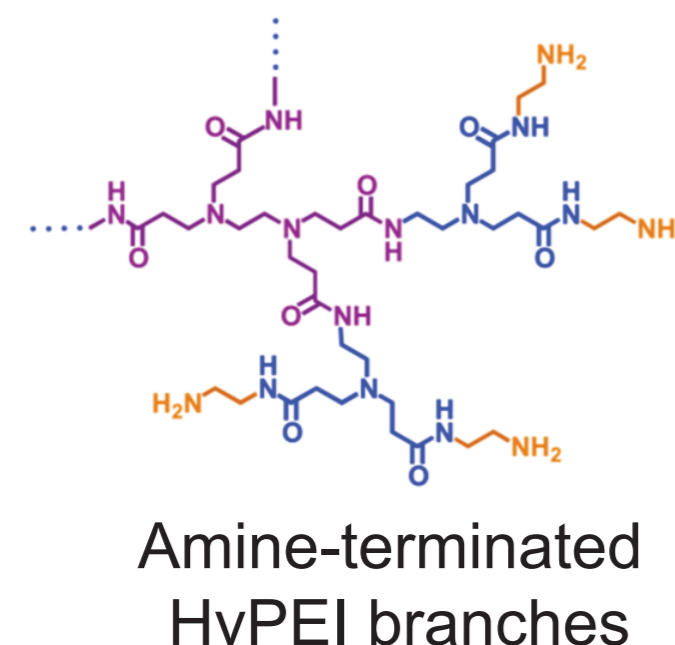
⁴Department of Civil Engineering, University of South Alabama

Introduction

We hypothesize that crude oil can be dispersed using dendritic polymers. Our objective is to compare dendritic polymers to Corexit 9500A (the dispersant used in the BP oil spill) taking effectiveness and toxicity into consideration.

Materials

- Hyperbranched polyethylenimine polymer, (HyPEI) with several molecular weights (1.2, 1.8, 10, 70, and 750 kDa)
- Corexit 9500A
- Louisiana light sweet crude (LLS) oil
- *Synechocystis* sp.
- *Dunaliella* sp.



Methods

Dispersant performance

- Premix the oil and polymer(or dispersant) at different DOR for 24 hours
- Add 20 ul premix to 12 ml artificial seawater, mixing at 200 rpm for 30min
- Settle for 15 min
- Collect 3 ml water sample from bottom of vials
- Extract dispersed oil in water sample with 1.5 ml dichloromethane (DCM)
- Test the absorbance at 340nm

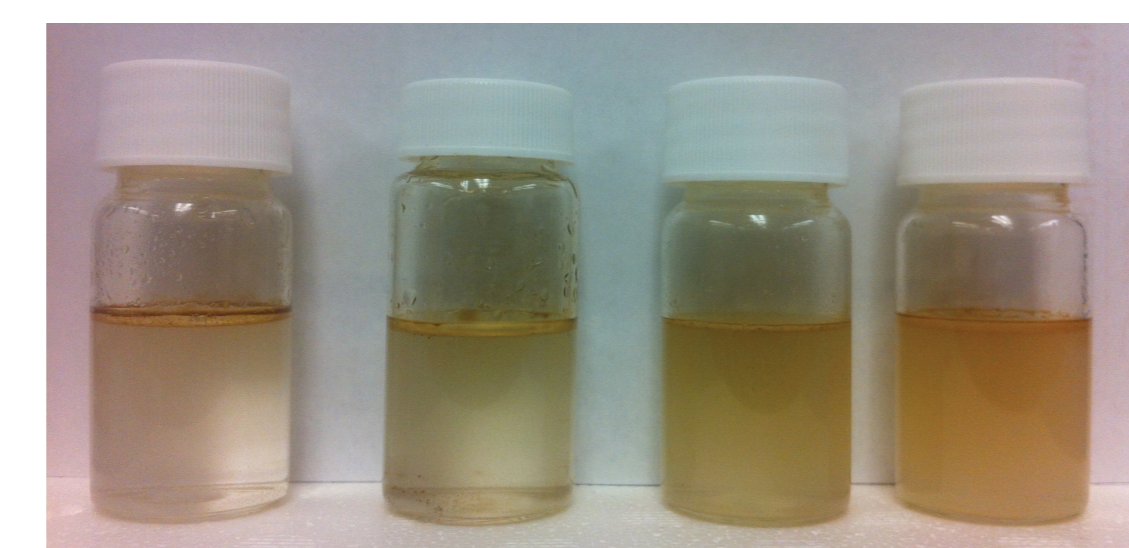
Interfacial tension

- Premix as in performance test
- Pendent drop and the axisymmetric drop shape analysis (ASDA) technique, Easy Drop@kruss
- Graph interfacial tension change with time

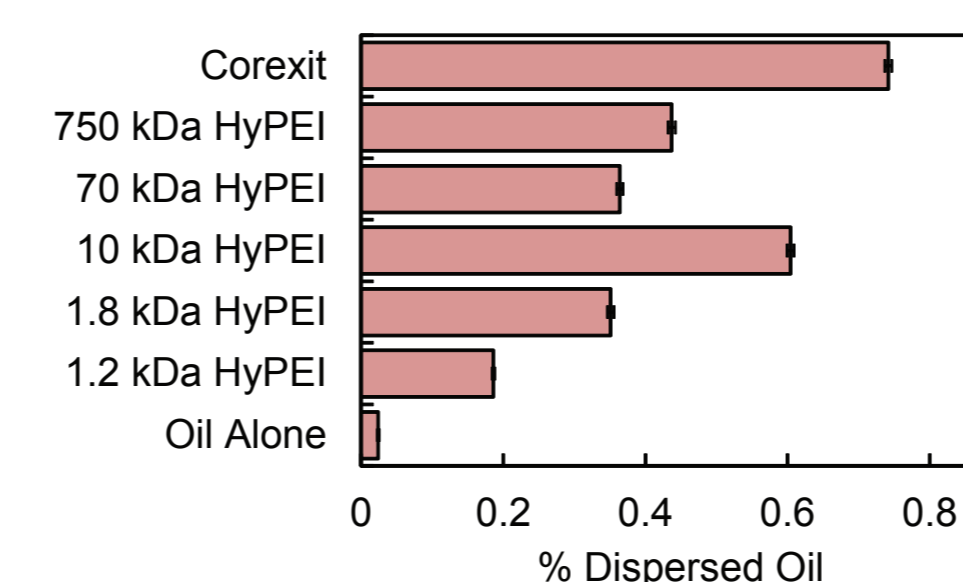
Algal growth inhibition

- Subculture two algal species in culture tubes with 10 ml media
- Add combinations of oil premixed with dispersant at various DORs into triplicate tubes.
- Grow under 12-hr light/dark cycle
- Measure absorbance daily at 685 nm

Dispersion performance results

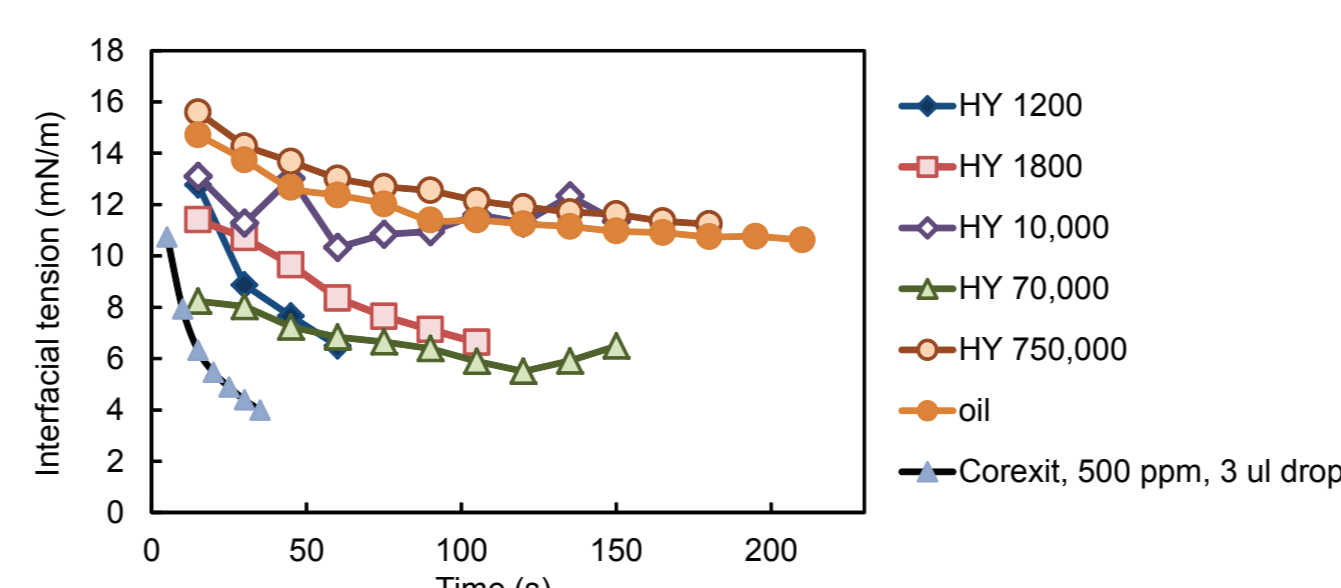
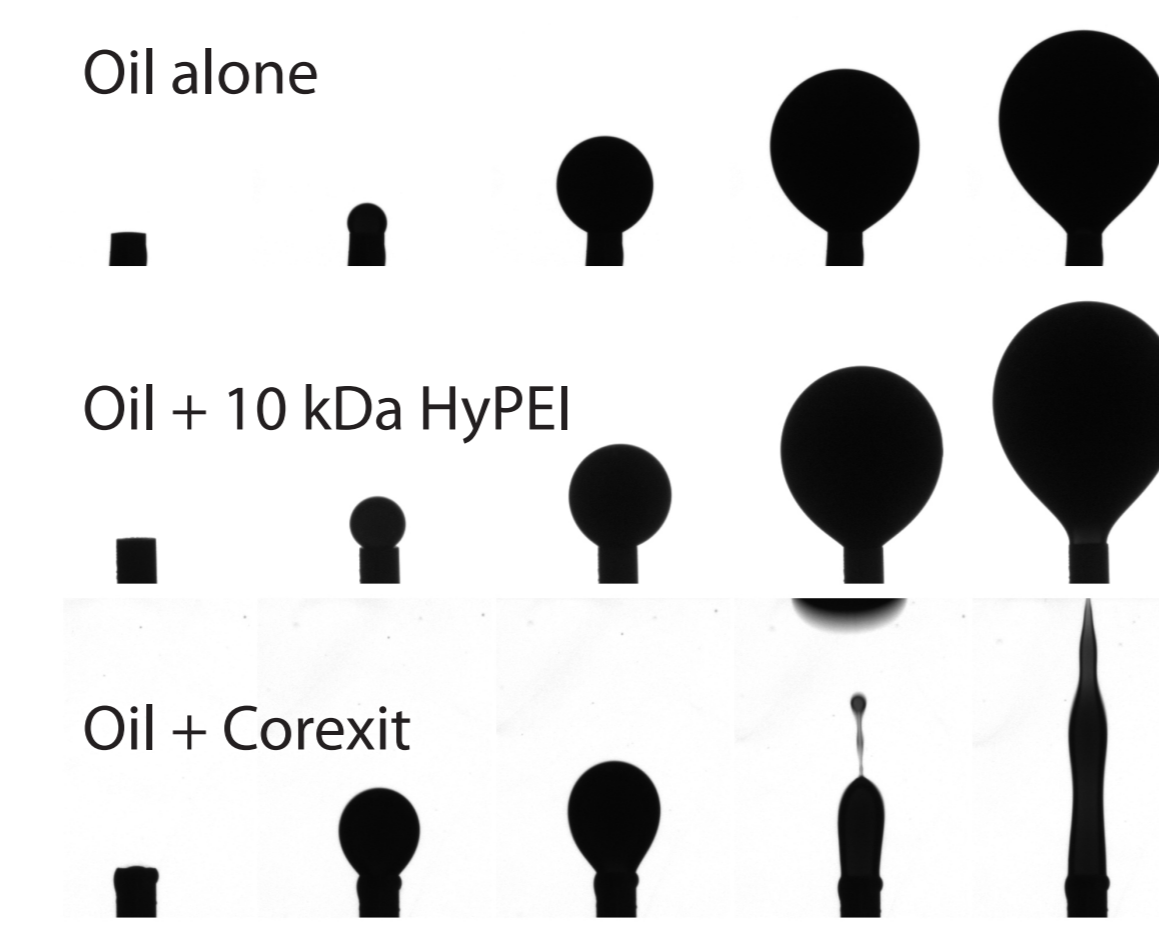


Left to right: oil, oil + 1.2 kDa HyPEI, oil + 10 kDa HyPEI, and oil + Corexit in water. Photo taken after mixing and standing 5 minutes. Qualitatively, the hyperbranched polymers disperse oil, though not as well as Corexit.



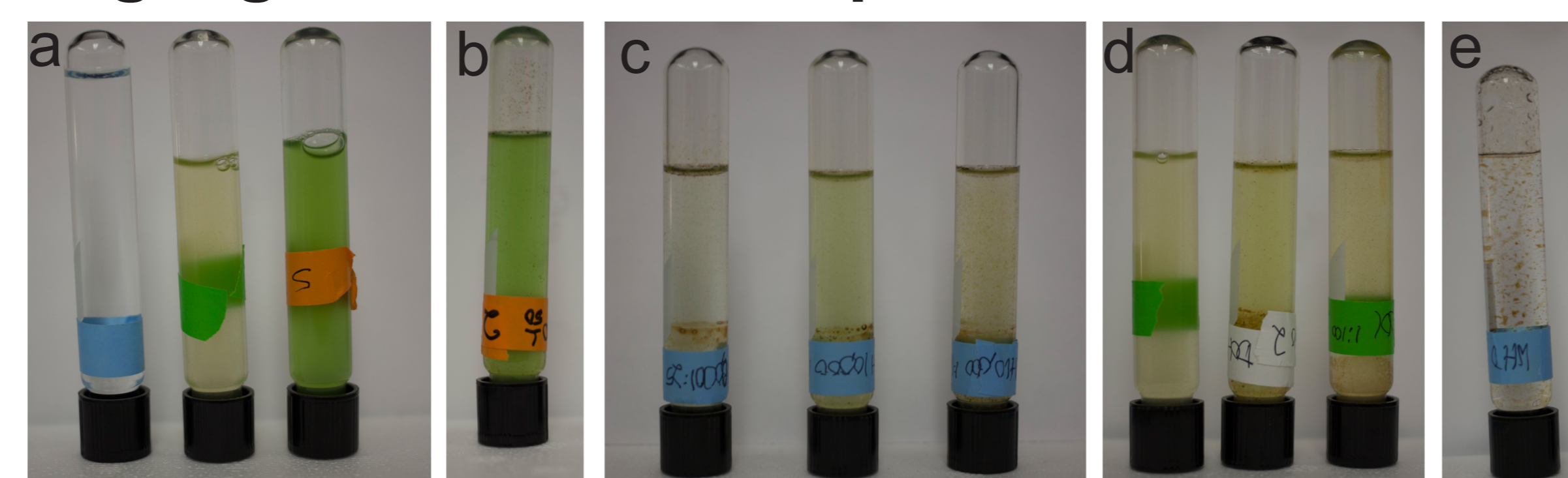
Effectiveness measurements with 1:50 dispersant:oil ratio (DOR) show that Corexit is best. Hyperbranched polymers have roughly increasing effectiveness with molecular weight, but the 10 kDa size bucks the trend.

Interfacial tension results



Even a low concentration of Corexit is effective at reducing interfacial tension, but the hyperbranched polymers are less effective; no clear trend with molecular weight is observed.

Algal growth inhibition photos

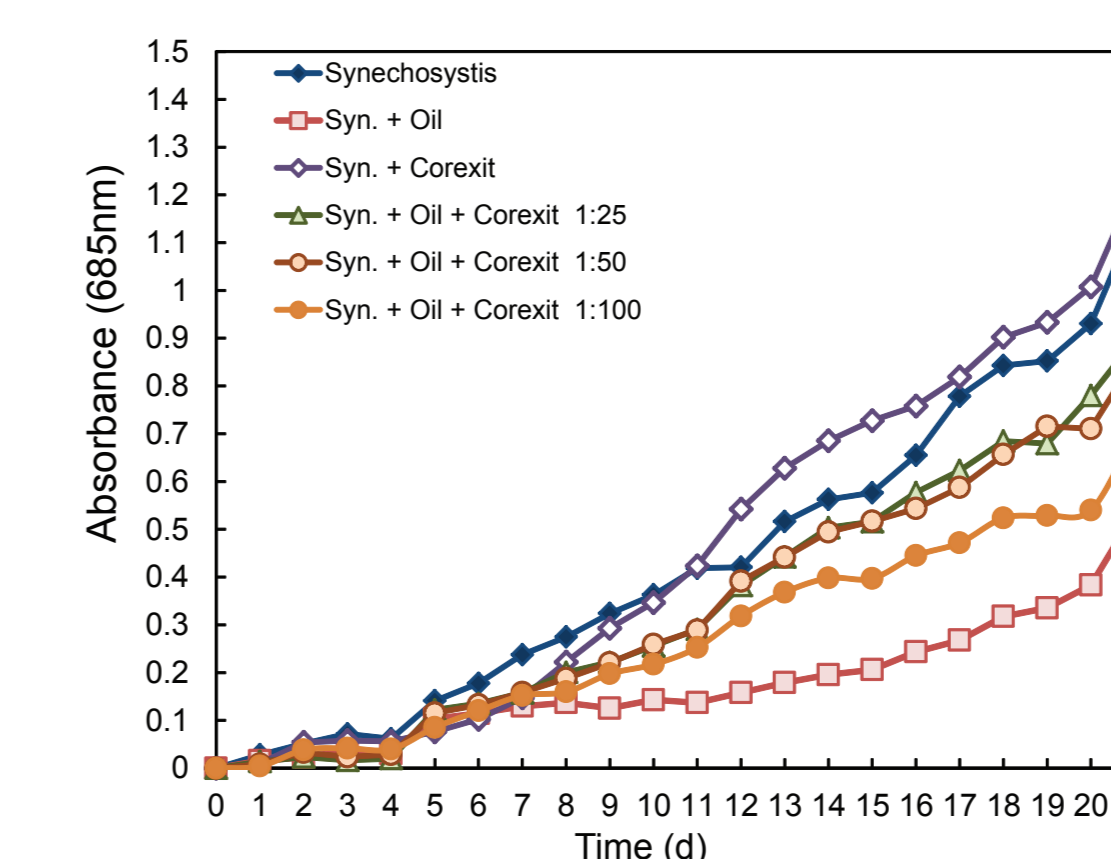


a. Water, *Dunaliella* alone, and *Synechocystis* alone
 b. *Synechocystis* + oil + 10 kDa HyPEI 1:50
 c. *Dunaliella* + oil + 10 kDa HyPEI at three DORs: 1:25, 1:50, 1:100.
 d. *Dunaliella* alone, *Dunaliella* + oil + 750 kDa HyPEI 1:100, and *Dunaliella* + Oil + Corexit 1:100
 e. Oil + 1.2 kDa HyPEI 1:25.

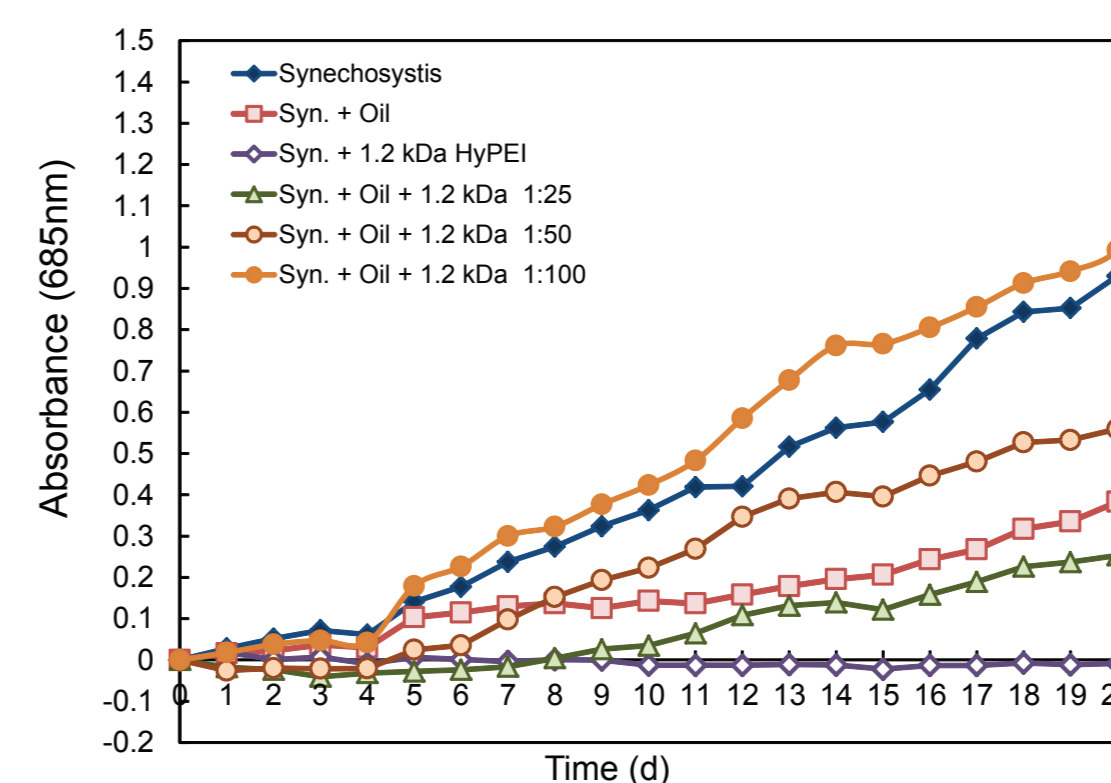
Conclusions

- Hyperbranched polymers, especially 10 kDa, were effective at dispersing oil, though not as effective as Corexit 9500. HyPEI did not decrease interfacial tension as well as Corexit.
- Corexit addition mitigated algal growth inhibition by oil. Some HyPEI polymers did the same, though the polymers alone often greatly inhibited growth.

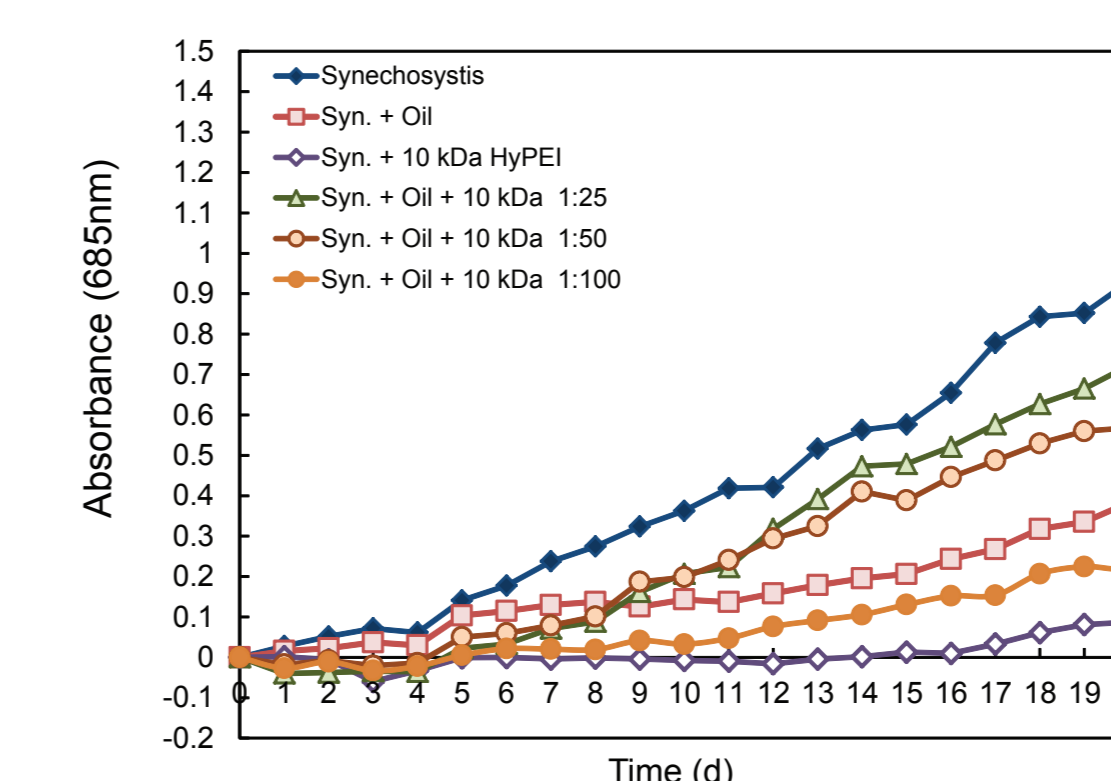
Algal growth inhibition results



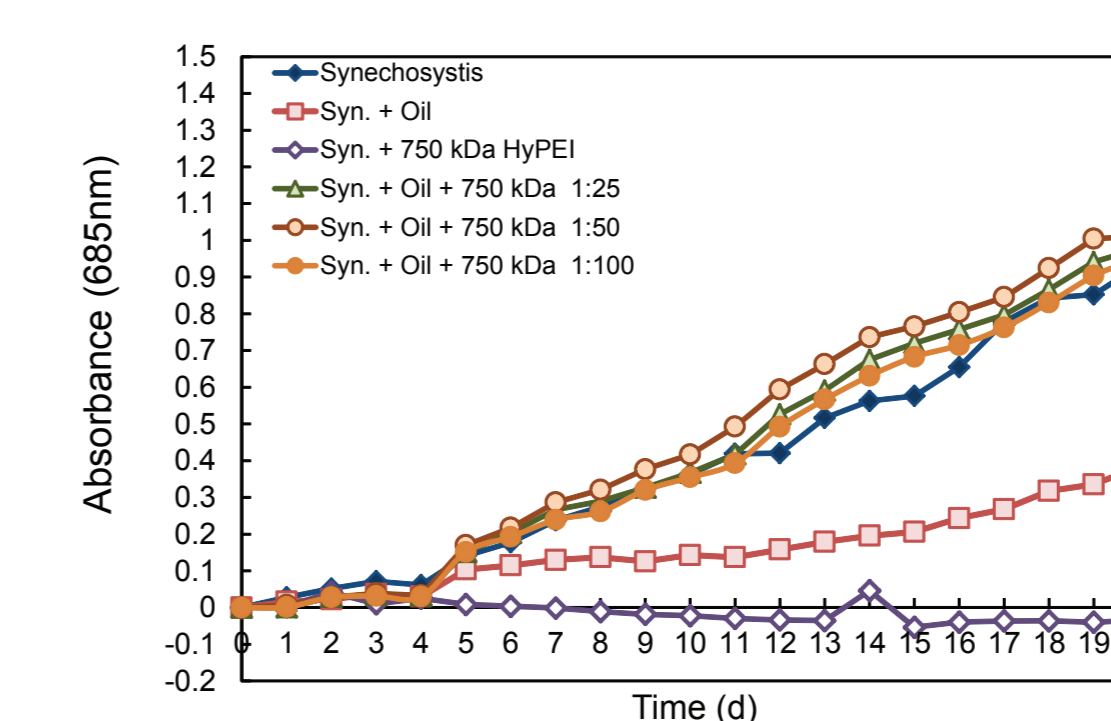
Synechocystis with Corexit. Corexit protected *Synechocystis* from oil contamination. Corexit alone did not seem to have an adverse effect on algal growth.



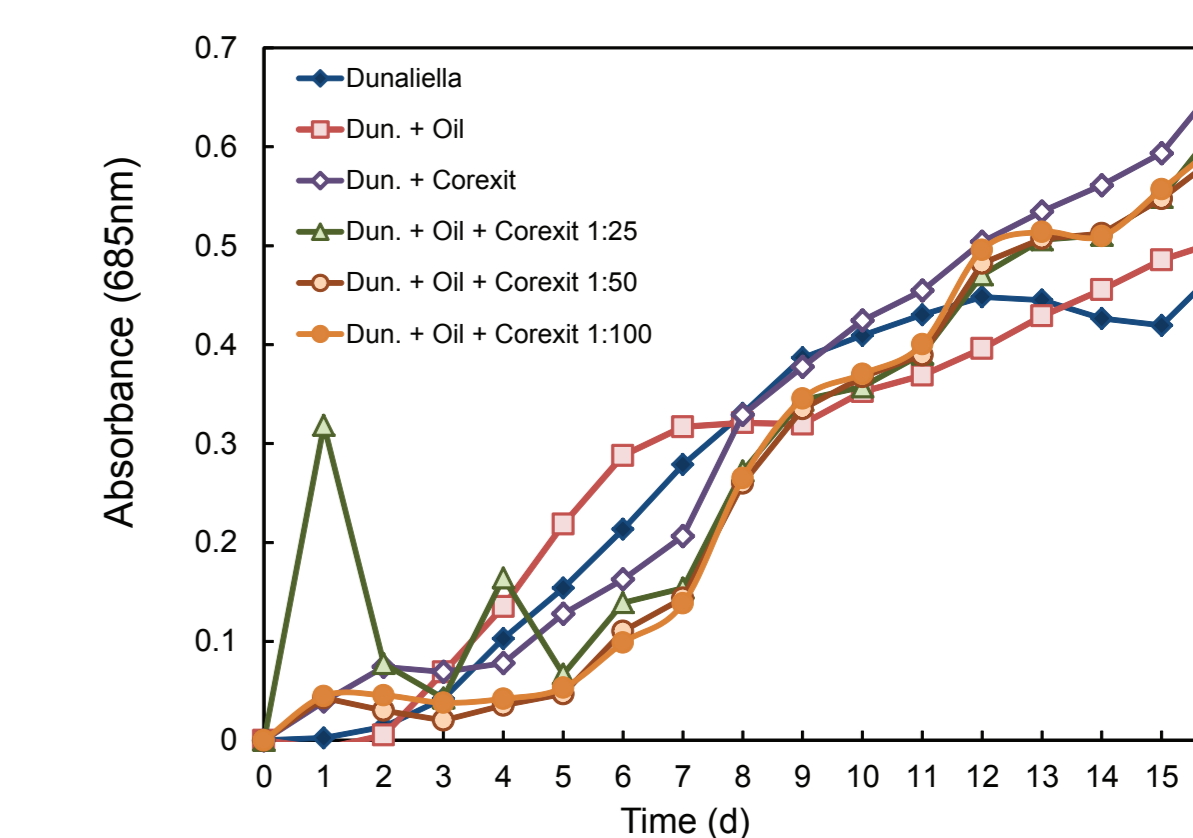
Synechocystis with 1.2 kDa HyPEI. 1.2 kDa seems to be a threat for algal growth. The higher the DOR, the greater the threat. 1.2 kDa HyPEI's toxicity reached its climax when it was applied alone without any oil.



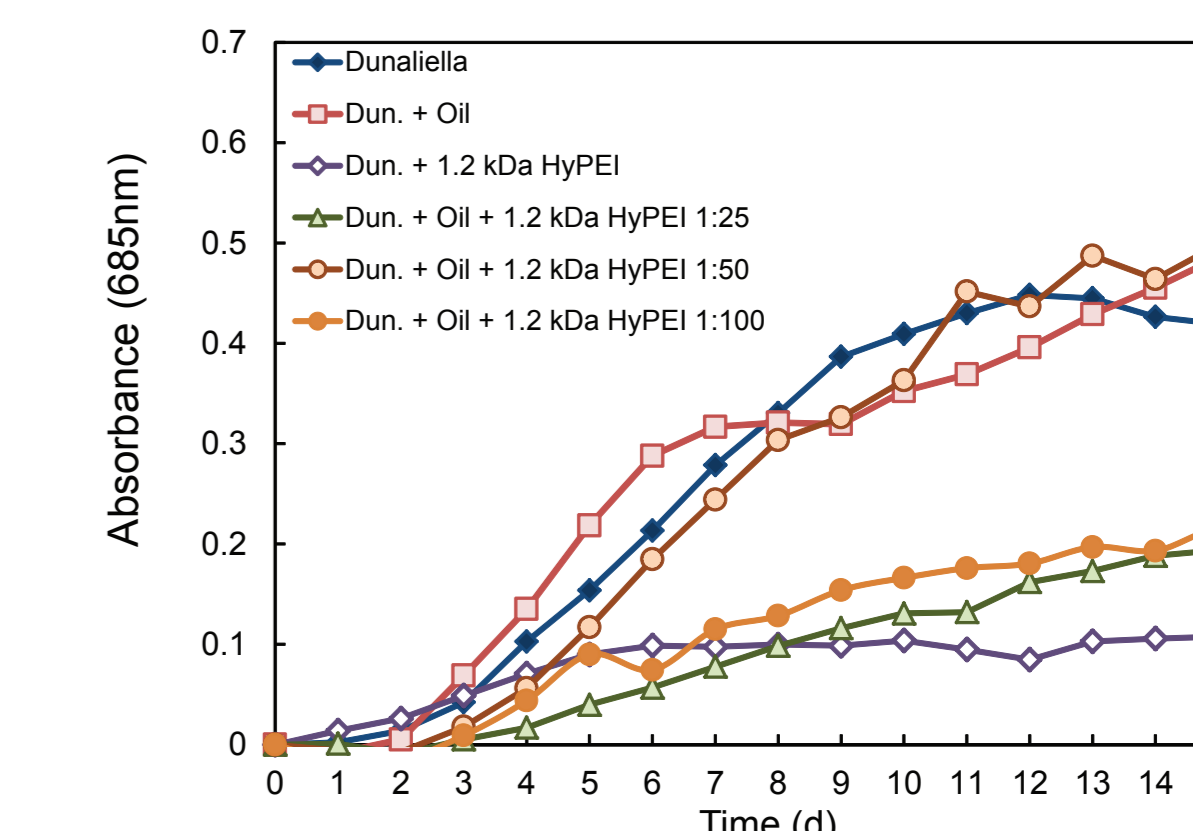
Synechocystis with 10 kDa HyPEI. 10 kDa seems to be a threat for algal growth, but the higher DOR, the less the threat. Only 1:100 showed higher toxicity than oil. 10 kDa HyPEI's toxicity reached its climax when it was applied alone without any oil.



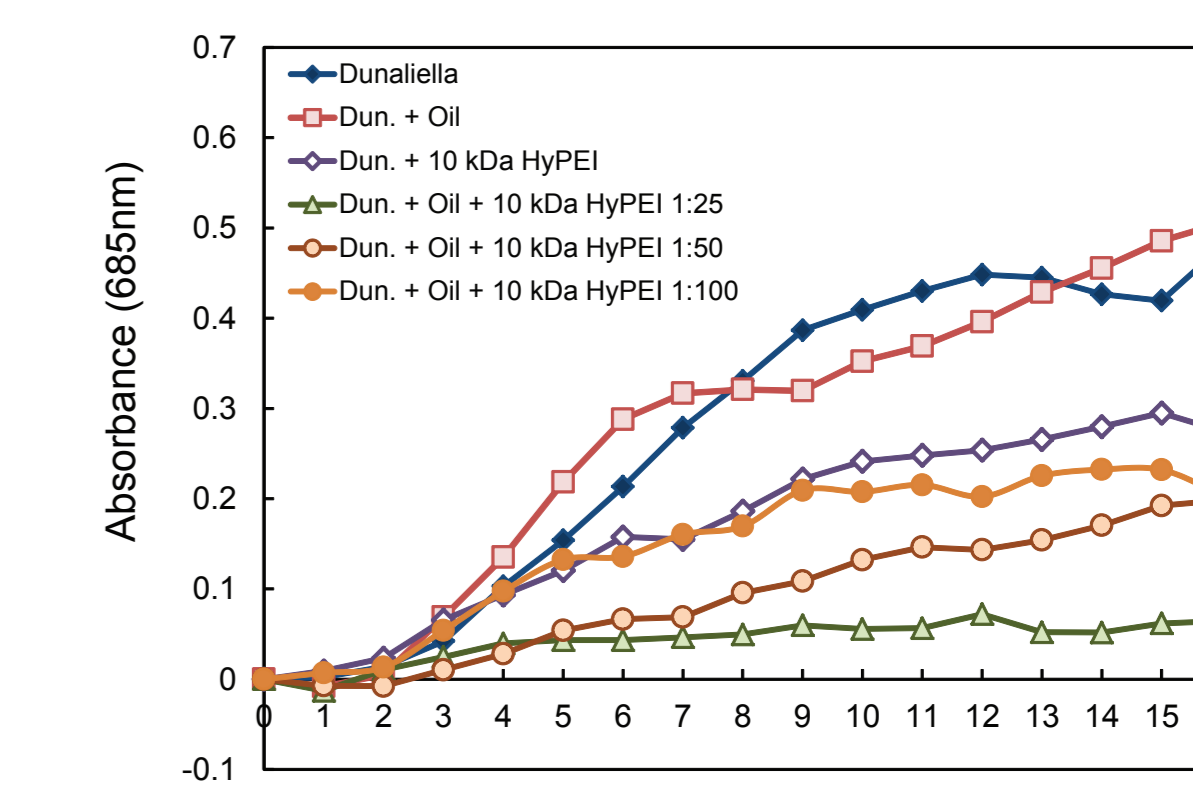
Synechocystis with 750 kDa HyPEI. 750 kDa HyPEI posed a greater threat and showed higher toxicity when it was applied without oil. But when it was mixed with oil, it seemed to have no adverse effect on algal growth. (70 kDa results were similar).



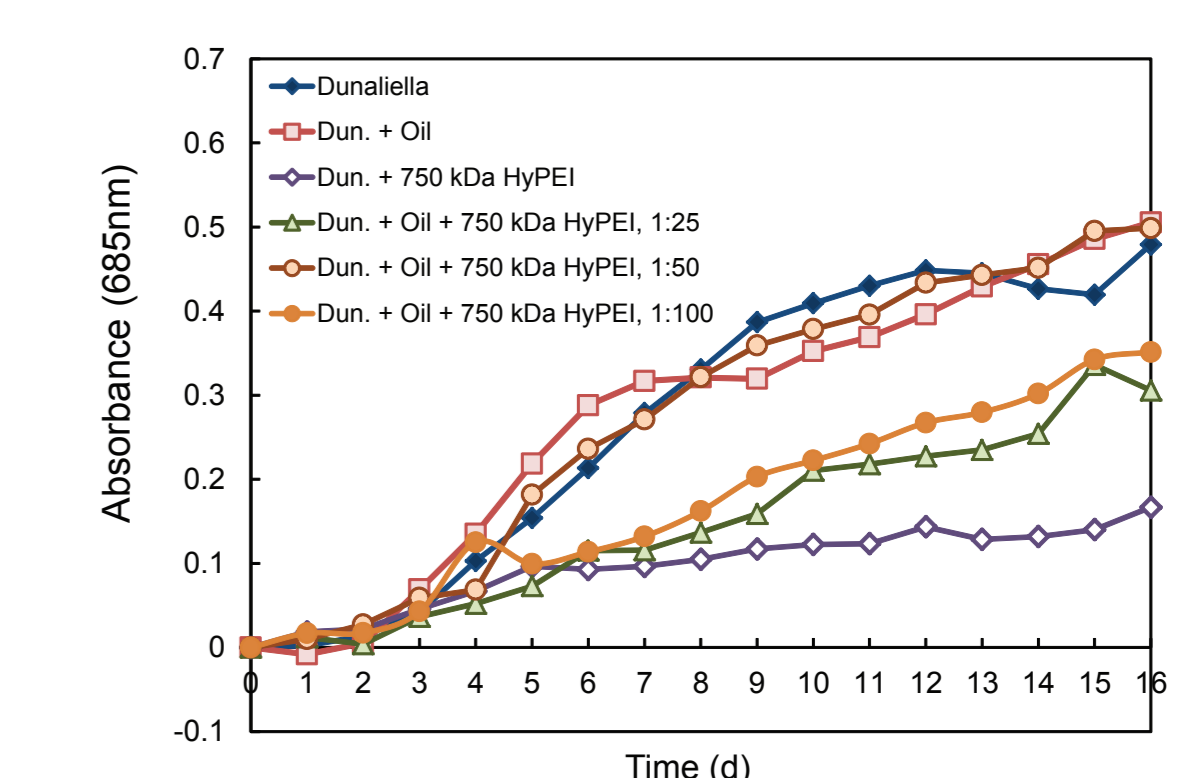
Dunaliella with Corexit. Corexit or oil seem to have no adverse effect on algae growth.



Dunaliella with 1.2 kDa HyPEI. The 1:50 DOR appears protective of algal growth. (Though in this set there was high variability in the other DORs).



Dunaliella with 10 kDa HyPEI. The 10 kDa HyPEI and oil combination showed higher toxicity than oil or 10 kDa HyPEI alone and the toxicity of the combination increased with the DOR.



Dunaliella with 750 kDa HyPEI. The 750 kDa HyPEI alone showed the highest toxicity and the toxicity of the oil and 750 kDa HyPEI combination was higher at DOR of 1:25 and 1:100, but showed no effect at DOR of 1:50.



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